Revista Mexicana de Biodiversidad

Revista Mexicana de Biodiversidad 96 (2025): e965459

Ecology

The sounds of love: acoustic repertoire of Andean bear, *Tremarctos ornatus* (Carnivora: Ursidae), mating in the wild

Sonidos amor-osos: repertorio acústico del oso andino **Tremarctos ornatus** *(Carnivora: Ursidae) durante el apareamiento en vida silvestre*

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Received: 14 March 2024; accepted: 11 October 2024

Abstract

Understanding animal behavior is crucial for effective mammal conservation efforts; however, limited knowledge exists regarding the behavioral patterns of many species, particularly in wild conditions. The Andean bear (*Tremarctos ornatus*) is the only ursid distributed in South America and is categorized as vulnerable to extinction by the IUCN. The information on various aspects of its natural history in wildlife conditions are scarce, including the ethology of its reproduction. In this study, we describe the sound repertoire emitted by *T. ornatus* during copulation and mating events in their natural habitat. Video recordings obtained from camera traps in Colombia and Bolivia were analyzed to identify and categorize vocalizations. The results revealed 5 distinct types of sounds emitted during copulation events: humm, grunt, whine, and snoar signals. Differences in vocalization patterns were observed between the male and female bears. Comparisons with existing literature suggest similarities with the vocalizations observed for other species. This study contributes valuable information to the understanding of Andean bear behavior and underscores the importance of acoustic communication in conservation efforts for cryptic species.

Keywords: Camera trapping; Colombia; Bolivia; Bioacoustics; Reproductive behaviour

ISSN versión electrónica: 2007-8706; Universidad Nacional Autónoma de México, Instituto de Biología. https://doi.org/10.22201/ib.20078706e.2025.96.5459

Resumen

Comprender el comportamiento de los animales es crucial para que los esfuerzos de conservación de los mamíferos sean eficaces, pero los conocimientos sobre los patrones de comportamiento de muchas especies, sobre todo en condiciones salvajes, son limitados. El oso andino (*Tremarctos ornatus*) es el único úrsido distribuido en Sudamérica, categorizado como vulnerable a la extinción por la UICN. La información sobre diversos aspectos de su historia natural en vida silvestre es escasa, incluyendo la etología de su reproducción. En este estudio describimos el repertorio sonoro emitido durante los eventos de cópula y apareamiento por *T. ornatus* en su hábitat natural. Se analizaron grabaciones de vídeo obtenidas con cámaras trampa en Colombia y Bolivia para identificar y categorizar las vocalizaciones. Los resultados revelan 5 tipos distintos de sonidos emitidos durante los eventos de cópula, incluyendo señales de "humm", "grunt", "whine" y "snoar". Se observaron diferencias en los patrones de vocalización entre machos y hembras. Las comparaciones con la literatura existente sugieren similitudes con las vocalizaciones observadas en otras especies. Este estudio contribuye con información valiosa a la comprensión del comportamiento del oso andino y subraya la importancia de la comunicación acústica en los esfuerzos de conservación de especies crípticas.

Palabras clave: Fototrampeo; Colombia; Bolivia; Bioacústica; Comportamiento reproductivo

Introduction

The study of animal behavior plays a fundamental role in mammalian conservation, as it provides valuable information on the relationships between species and their environment (Berger-Tal et al., 2016). Understanding species behavioral patterns is crucial for designing effective conservation strategies, as it allows scientists to identify and address key factors influencing population dynamics, habitat utilization, and overall ecological balance. A thorough understanding of animal behavior is essential for developing informed and adaptive conservation practices that safeguard species diversity. In many cases, knowledge of the behavior of wild species of large mammals comes from captive conditions (Jayne & See, 2019). Although captivity provides a controlled environment for observation, it can inadvertently influence animal behavior. Captive individuals exhibit altered behaviors as they are subjected to artificial conditions, restricted spaces, and stimuli provided by humans. This can lead to biased results that do not accurately reflect the natural behavior of their wild counterparts. Even so, information on wild conditions is scarce for many species, considering the difficulties in directing encounters without altering individual behavior.

Few studies have focused on the social behavior and vocalizations of ursids (Wemmer et al., 1976). The first studies on this subject were done by Meyer-Holzapfel (1957), who mentioned several calls of different species; Krott and Krott (1962) described the vocalizations of the European brown bear (*Ursus arctos*, Carnivora: Ursidae), and Jonkel (1970), Jonkel and Cowan (1971) described calls used in agonistic contexts by North American bears, while Negus (1949) in his study of the vertebrate larynx reported that bears are generally silent.

Fortunately, advances in remote sensing technologies have provided us with opportunities to explore animal behavior. The scarcity of information on the ecology of the Andean bear has been changing in recent years owing to the use of tools such as camera traps, which have allowed us to obtain more information about the species, and the recording of various behaviors such as courtship, maternal care, and copulation events has been achieved (Appleton et al., 2018; Castellanos, 2015; Reyes et al., 2018, 2024). The objective of this study was to describe the vocalizations emitted by Andean bears during copulation events in the wild.

Materials and methods

Video records were obtained using camera traps during the copulation of wild bears in 3 locations: 2 in Colombia and 1 in Bolivia (Fig. 1). The first was in the Department of Huila (Colombia): the mating event was recorded by the SERANKWA monitoring group in a Cuddeback camera trap located in the site called "El Rascadero" (1°49'35.06" N, 76°23'35.41" W, WGS84), in the Natural Reserve of the Civil Society La Loma del Toro Pao in the Municipality of San Agustín at 2,410 m asl, the reserve has areas of forest cover in good condition (Parques Nacionales Naturales de Colombia, 2017). The second locality was in the department of Cundinamarca (Colombia): this mating event was recorded by the Corporación Autónoma Regional de Cundinamarca- CAR, Dirección de Recursos Naturales, Grupo de Biodiversidad in 2 camera traps (Bushnell Trophy Cam HD) in the municipality of Guatavita (4°54'0.06" N; 73°44'21.56" W and 4°53'58.65" N, 73°43'40,47" W, WGS84), in the Eastern Cordillera (Anillo Oriental) of the Colombian Andes in the buffer

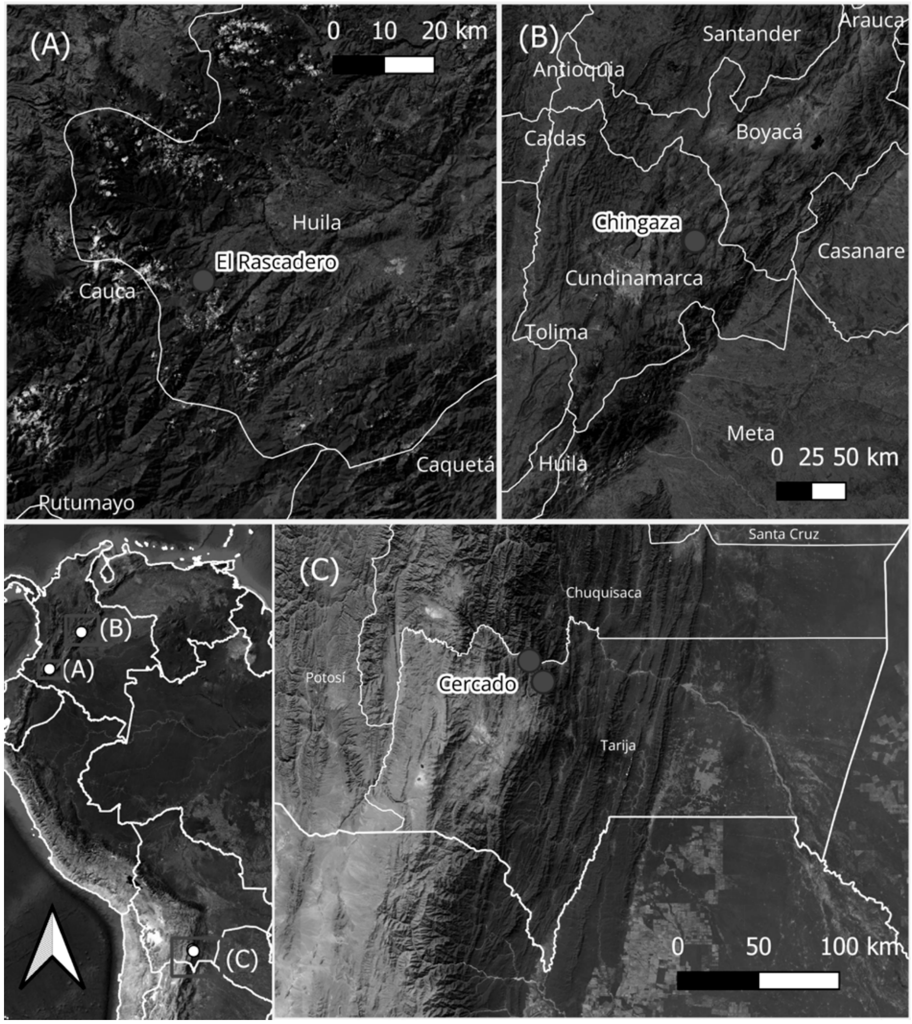


Figure 1. Location of study sites. A) El Rascadero, Huila, Colombia; B) Chingaza, Cundinamarca, Colombia; C) Cercado, Tarija, Bolivia. Map by Angela M. Mendoza-Henao.

zone of Chingaza Natural Park, which includes Andean and high Andean forests between 2,500 and 3,000 m asl. The third locality is in Tarija department (Bolivia): mating event was recorded in 2 camera traps (Bushnell Trophy Cam HD Aggressor) 15.8 km from Hoyadas Cercado, Cercado Province (21°7'29.10" S, 64°25'16.90" W and 21°14'39.00" S, 64°20'12.90" W, WGS84), between 930 and 3,400 m asl.

The videos were manually examined to identify those with vocalizations and, to the extent possible, to assign the signal to the male or female. WAV files were generated from the selected videos. Information on the times of vocal activity was obtained from camera trap metadata. Acoustic parameters were obtained using Raven 1.6.2 (K. Lisa Yang Center for Conservation Bioacoustics): call duration, minimum and maximum frequency were obtained using 5% and 95% values with a window size of 1,024 and a Hann algorithm. The final recordings were deposited in the Colección de Sonidos Ambientales "Mauricio Álvarez-Rebolledo" of the Instituto de Investigación de Recursos Biológicos Alexander von Humboldt of Colombia (IAvH-CSA-37506 to IAvH-CSA-37510). The vocalization parameters were summarized and described for each event.

Results

Vocalizations or sounds were obtained from the 6 copulation events analyzed (3 from Colombia and 3 from Bolivia), with some differences in audio quality due to the camera trap brands and models, and the distance of the individuals from the equipment. During the analysis, we were able to classify 5 different types of sounds according to the shape of the spectrogram (Table 1), following the terminology of vocalization descriptions of other ursids (Peters et al., 2007; Pokrovskaya, 2013).

Regarding the Cundinamarca events in Colombia, mating occurred on September 14, 2021, between 11:36 and 12:33 hrs. (camera 4), and between 14:24 and 15:51 hrs. (camera 5). Acoustic signals were detected in 55 videos from both sites (Fig. 2). All the sounds recorded were presented when the male is on the female, in the videos it is observed how both the male and the female emit different sounds in the process of copulation. In general, all the recorded sounds are of the copulation process. A total of 33 sounds between vocalizations and snorts were emitted by females and 48 by males. For the remaining vocalizations, individual correspondence could not be verified. The bears mostly emitted humm-type vocalizations, which in some cases were preceded or followed by other types of vocalizations. During the time of copulation, both videos and sounds show some moments of aggressiveness of the male towards the female, this is evident in an event where the male bites the neck of the female and she emits a very high-pitched sound (bite-type vocalization, Fig. 2). Table 2 summarizes the main quantified parameters of the signals.

For events in Bolivia, 2 videos from station PI072 included sound information (Fig. 3a). The recorded vocalizations included humm, grunt and whine signals emitted simultaneously by males and females. Snort-type vocalizations were dominant in both the recordings. These recordings provided information on frequencies below 5 kHz, and harmonics up to 10.16 kHz in frequency were detected. Four of the videos from station PI012 included sounds from a single individual in sight (Fig. 3b), recorded at 6:42 am and between 10:37 am and 10:41 am. All signals were humm with 9 - 22 pulses with a dominant frequency at 344.53 ± 54.47 Hz and a second harmonic frequency with the highest energy at 6,488.67 ± 611.07 Hz with frequencies covering a bandwidth of 8,641.99 ± 886.23 Hz. The mean signal duration was 1.035 ± 0.33 s. Finally, a single video from station PI071 from 2022-10-29 includes a series of sounds made by a single individual (sex unknown, Fig. 3c) including humm (dominant frequency of 301.46 Hz and duration of 0.96 s), whine (dominant frequency of 172.2, duration of 3.52 s) and snoar (dominant frequency at 3,200 Hz for 2 signals and 872.1 for the remaining 4, total duration of 0.255 s) type signals.

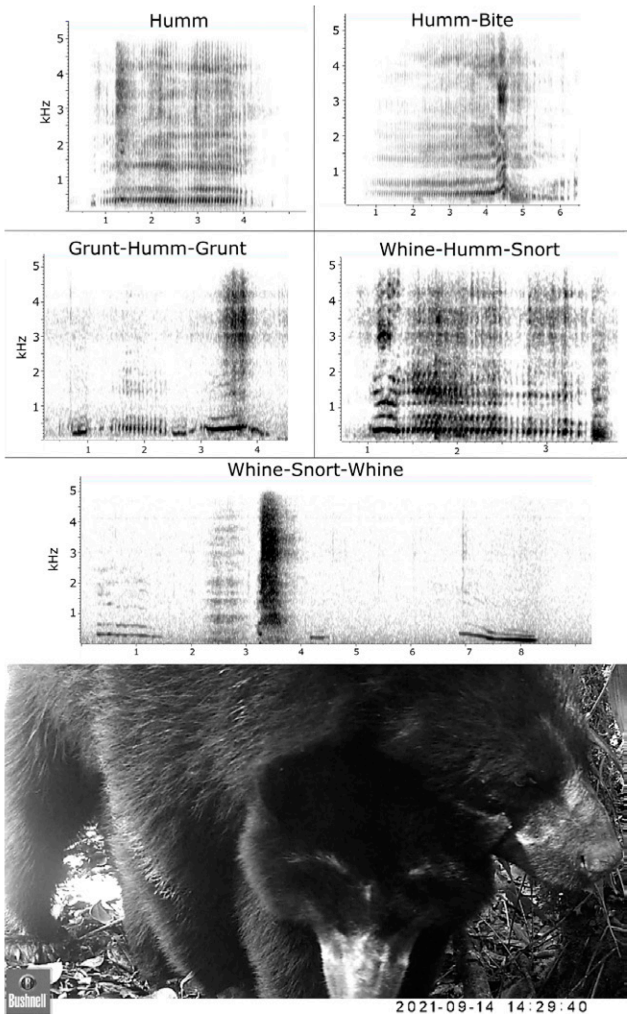


Figure 2. Spectrograms of the 6 types of *Tremarctos ornatus* signals emitted during the mating event in Cundinamarca, Colombia.

The mating event in Huila (Colombia) occurred on February 9, 2020, between 08:14 and 13:03 hrs. The second copulation event was recorded at the same site on February 13, 2020, between 14:05 and 17:17 hrs. (56 videos and 49 photographs). The camera had a sound filter above 5 kHz, which limited the availability of data beyond this frequency. Acoustic signals were detected in only 28 of 122 videos. Five videos in the interval between the 2 mating events also had acoustic signals. Owing to the sound quality of the camera and the distance of the pair, the signal was sufficient in only 1 video to extract some spectral parameters (Fig. 4). In this case, the call was probably a 2.196 second humm-type vocalization, with frequencies between 1,125.0 and 1,843.75 Hz (dominant frequency 1,625.00 Hz).

https://doi.org/10.22201/ib.20078706e.2025.96.5459

Table 1

Description of the type of acoustic signals of *Tremarctos ornatus* during courtship and copulation events and spectrogram example of each one (1 second section).

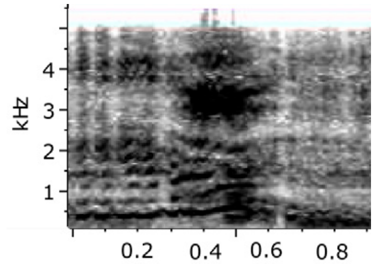
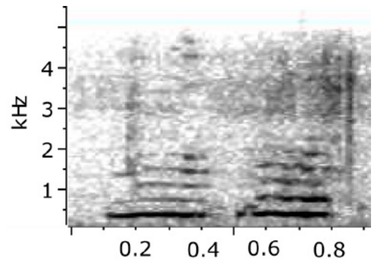
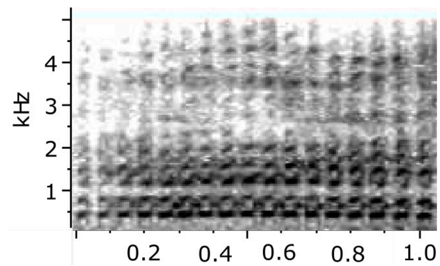
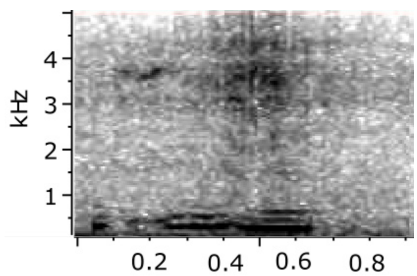
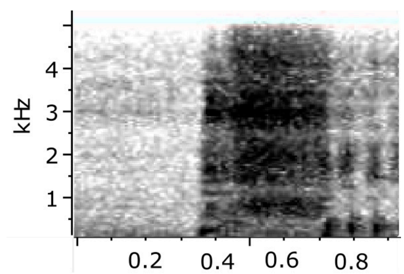
Sound type	Description	Spectrogram
Bite	This type of signal shows an abrupt increase in frequency and amplitude and was only emitted by the female.	
Whine	This signal is a long note with a slight frequency modulation. In some cases, it is possible to detect harmonics in this signal up to 5 kHz. We did not recover these types of signals from the male.	
Humm	It is the most common type of vocalization and is emitted by both males and females. This signal consists of a series of short, low-frequency “pulses” at constant speed, with sporadic frequency modulation and variable duration (up to 8.9 seconds).	
Grunt	This signal is similar to the whine type, but shorter and with fewer harmonics.	
Snort	Unlike the aforementioned vocal signals, snort is probably a nasal emission covering a broad range of frequencies. It was emitted mainly by the male.	

Table 2

Summary of the main signal parameters for mating in Cundinamarca (Colombia). Spectral values are given in Hz and signal duration in seconds. Values for more than 3 signals mean ± standard deviation.

Type	Sex	N	Dom freq	Min freq	Max freq	Freq bandwidth	Signal duration
Bite	F	2	1,679.55 ± 1,888.05	301.45 ± 121.83	2,045.65 ± 1,979.40	1,744.20 ± 1,857.57	0.550 ± 0.495
	NA	2	344.50 ± 0.00	193.80 ± 30.41	925.95 ± 700.39	732.15 ± 730.79	1.650 ± 0.071
Grunt	M	8	220.70 ± 101.49	134.58 ± 104.09	613.70 ± 713.54	479.13 ± 610.10	0.213 ± 0.164
	NA	14	196.88 ± 62.55	153.81 ± 43.78	310.69 ± 117.26	156.88 ± 90.36	0.407 ± 0.327
Whine	F	5	516.78 ± 337.73	353.14 ± 47.19	1,326.44 ± 315.59	973.30 ± 309.94	0.420 ± 0.409
	NA	41	259.45 ± 101.22	199.58 ± 73.82	638.65 ± 627.49	439.06 ± 589.26	0.478 ± 0.442
Humm	F	25	821.70 ± 1,090.34	246.35 ± 82.02	2,322.15 ± 1,024.95	2,075.80 ± 1,002.38	2.112 ± 1.568
	M	24	434.25 ± 545.76	254.81 ± 175.48	1,492.98 ± 1,132.87	1,238.17 ± 1,059.89	1.071 ± 0.765
	NA	310	329.52 ± 224.89	229.37 ± 59.32	1,149.46 ± 853.06	920.10 ± 847.90	1.331 ± 0.791
Snoar	F	1	344.50	301.5	1,507.30	1,205.8	1.2
	M	16	788.64 ± 1,100.30	183.03 ± 172.63	1,924.53 ± 1,430.22	1,741.50 ± 1,346.52	0.275 ± 0.284
	NA	5	1,834.60 ± 1,522.19	611.54 ± 532.20	3,307.48 ± 1,172.88	2,695.94 ± 1,110.42	0.240 ± 0.114

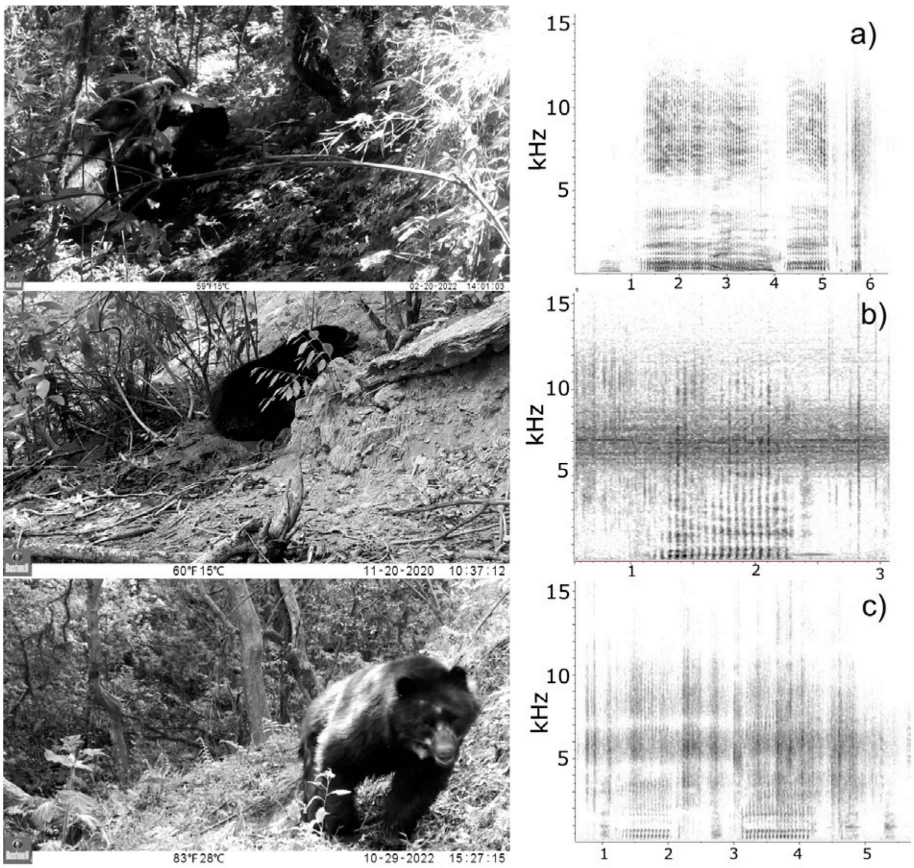


Figure 3. Mating events and spectrograms of *Tremarctos ornatus* signals emitted during the mating event in Tarija, Bolivia. a) Camera PI072, b) camera PI012 y c) camera PI071.

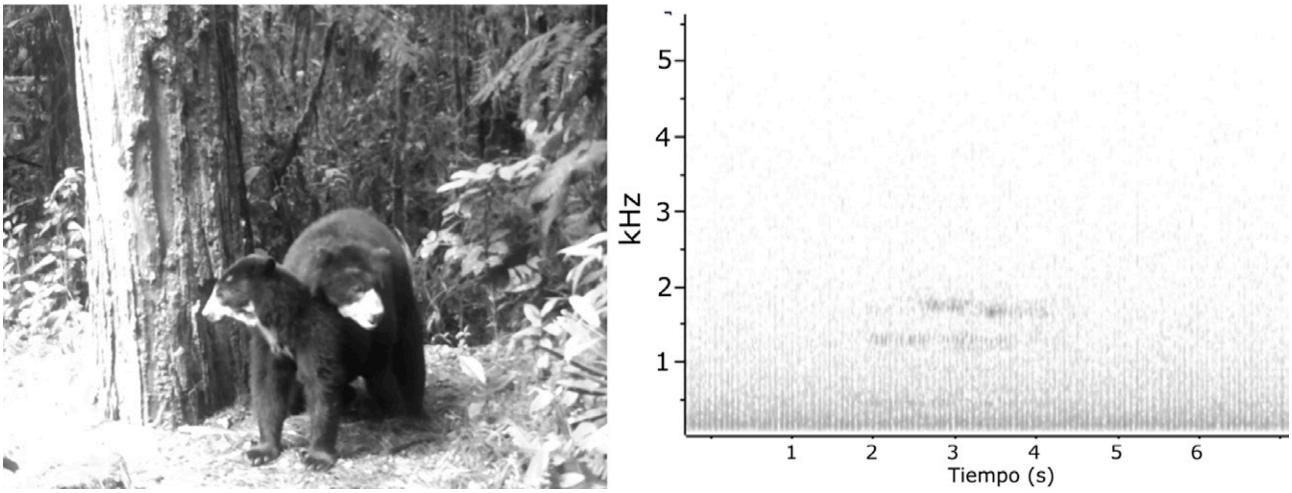


Figure 4. Mating events and spectrogram of *Tremarctos ornatus* signals emitted during the mating event in Huila, Colombia.

Discussion

This study provides the first description of the acoustic mating repertoire of *T. ornatus* based on quantitative measurements of in-situ vocalizations. In general, for ursids, some descriptions of vocalizations correspond to verbal or onomatopoeia-based descriptions (Pokrovskaya, 2013), which makes it difficult to make rigorous quantitative comparisons between species or between different social contexts of communication. For example, Castellanos et al. (2005) differentiated 6 sound types for 2 *T. ornatus* individuals in the process of reintroduction. Following Pokrovskaya's (2013) synonyms of signal types, the sounds named by Castellanos et al. (2005) as guttural (kurrrrr or tuutuctttt) would be analogous to humm-like signals but could also correspond to a signal type called "chuffing" described for other ursids, with differences in structure in comparison to humm signals. Scream-like sounds could be analogous to bite but could also be referring to grunt type signals; short puffs would be analogous to snorts, and whines (eggmmmmmmmm) may be like whine. Given the limited nature of this differentiation and the lack of available recordings, it is impossible to make an assignment or rigorous comparison.

Knowledge of the vocalizations of this species has been restricted to captive conditions, especially from interactions between females and their cubs (Elowson, 1988; Peters et al., 2007). When comparing the available quantitative information, we found similarities in the frequencies of our humm-type signals (821.70 ± 1,090.34 Hz in females, 434.25 ± 545.76 Hz in males and 329.52 ± 224.89 Hz in undetermined cases) with the mother and pup signals termed trill (418 ± 39 Hz for mothers and 375 ± 104 Hz for pups). Grunt-type signals had slightly higher frequencies in our records (220.70 ± 101.49 Hz in females and 196.88 ± 62.55 Hz in indeterminate cases vs. 175 ± 35 Hz for mothers). Whimper-type sounds of cubs (347 ± 181 Hz) were within the frequency range of our records for whine-type signals (516.78 ± 337.73 Hz for females and 259.45 ± 101.22 Hz for indeterminate cases). It should be noted that it would be ideal to make spectrogram comparisons directly for a more detailed comparison, as the dominant frequency alone may not be sufficient for describing and comparing these signals.

In recent information on *T. ornatus*, Vela-Vargas et al. (2021) mentioned that vocalizations are composed of tonal and atonal elements with ranges from 0.01 to 7 kHz; however, they did not report the source of this statement. Based on the information obtained in the Bolivian camera traps in our study, we can identify harmonics at high frequencies, even up to 12 kHz, and the highest energy of the signals includes a frequency band of 8,641.99 ± 886.23 Hz. In this sense, our work reports a wider use of frequencies by *T. ornatus* than reported to date. This was made possible by the quality of sound recordings from the camera traps used at these sites, demonstrating that advances in the quality of audio recordings from the equipment can provide useful information on multiple aspects of the biology of these species.

The degree of vocalization of bears varies by species. Herrero (1978) suggested that black bears are more vocal than brown bears, because they inhabit denser vegetation and have restricted visibility. Historically, closed area ursids, such as Andean bears (*Tremarctos ornatus*), sloth bears (*Melursus ursinus*), and sun bears (*Helarctos malayanus*) are considered quite vocal (Laurie

& Seidensticker, 1977; Peyton, 1980). Pandas (*Ailuropoda melanoleuca*) in zoos vocalize during estrus (Kleiman et al., 1979), whereas wild pandas have a repertoire of approximately 11 identifiable sounds (Schaller et al., 1985). Polar bears (*Ursus maritimus*) vocalize little (Stirling & Derocher, 1990), females and cubs may call each other if separated, or if the female leaves a location and wants the cub to follow. Males snort and snort during intrasexual agonistic behavior but otherwise lack distinctive calls that characterize other carnivores (Wemmer et al., 1976).

Considering the possibility that these signals are also emitted in other social contexts (e.g., during play or in interactions with individuals of the same sex), this study constitutes an important contribution to the knowledge of the reproduction and communication of this species in the wild. Knowledge of acoustic communication could contribute to conservation outcomes if behaviors associated with such communication provide information about a population exposing a conservation problem or if responses to conservation actions are monitored (Teixeira et al., 2018). By identifying and characterizing vocalizations during copulation events, our findings open new opportunities for the use of acoustic data in field sampling. For cryptic species, detection using passive acoustic methods may be an efficient and cost-effective method (Williams et al., 2018), complementing existing methods such as camera trapping. Finally, this work underscores the importance of storing such valuable acoustic recordings in public repositories, as these datasets can serve as a resource for researchers worldwide (Lozano-Florez et al., 2021, Mendoza-Henao et al., 2023). Considering that many camera trap videos may already contain unexplored audio data, encouraging the proper archiving and sharing of these materials could greatly enhance our collective understanding of species behavior and communication, encouraging collaborations and further research on terrestrial mammals like *T. ornatus*.

Acknowledgments

We would like to thank all the members of the Red de Reservas Naturales de la Sociedad Civil Serankwa, Camilo Augusto Agudelo Perdomo, Director of the CAM and Luis Fernando Sanabria Martínez, Director of the CAR, Directorate of Natural Resources, Biodiversity Group for providing the records for the preparation of this article.

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